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First syntaxonomical contribution to the invasive *Ailanthus altissima* (Mill.) Swingle forest communities at its southern limit in Europe

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Abstract

Ailanthus altissima (tree of heaven), an invasive alien tree native to China, has become invasive all over the world and in Italy is present in all the administrative regions where it can form dense forest communities. Although there are several ecological studies on this species there is a lack of floristic-vegetational data for southern-Europe. The study presents the results of a floristic vegetational study on *A. altissima* forest communities of central Italy that aims to highlight the possible floristic-vegetational autonomy of these coenoses. The results have allowed the characterization of *A. altissima* coenoses at the ecological, biogeographic, syntaxonomic and landscape levels. These represent first *A. altissima* syntaxa described for the Italian peninsula and for southern-Europe. We propose two new sub-Mediterranean and Mediterranean associations comprised in the recently described alliance *Lauro nobilis-Robinion pseudoaciae*, in the *Chelidonio-Robinietalia* order and the *Robinietea* class: *Asparago acutifolii-Ailanthetum altissimae*: forest community with stratified structure and high canopy density on the warmer slopes of the hills in dry soil conditions and low anthropic disturbance and *Aro italici-Ailanthetum altissimae*: paucispecific forest communities with a monolayered structure typically found in agricultural, and peri-urban areas on pelitic, alluvial silty-sandy substrates, in conditions of edaphic humidity and high anthropogenic disturbance. The comparison with literature data highlights the autonomy of these associations of the sub-Mediterranean and Mediterranean alliance *Lauro nobilis-Robinion* pseudoacaciae alliance from the *Balloto nigrae-Ailanthetum altissimae* association of the Central and SE-European *Balloto nigrae-Robinion pseudoacaciae* alliance.

Keywords

Ailanthus altissima, alien forest communities, invasive alien species, Mediterranean and sub-Mediterranean climate, plant landscape, *Robinietea* class, syntaxonomy

Introduction

The invasion of alien plants is a global process derived from the human–mediated introduction of a species outside their habitat of origin (Richardson and Pyšek 2006; Van Kleunen et al. 2015). Biological invasions constitute one of the major threats to biodiversity and ecosystem services provided by native ecosystems (Simberloff et al. 2013; Lazzaro et al. 2020; Montecchiari et al. 2020a) causing both ecological, economical and health impacts (Lonsdale 1999; Pimentel et al. 2000; Touza et al. 2008; Vilà and Hulme 2017).

Ailanthus altissima is one of the most widespread invasive alien species (IAS) in Europe (Lambdon, et al. 2008; Pysek et al. 2009) and was recently added to the list of IAS of Union concern (European commission 2019). It is a tree native to China and introduced in Europe (France) in 1740 (Kowarik and Saumel 2007). It quickly spread in Central and southern Europe in urban and peri–urban areas, but also in the agro–forest environment (Gutte et al. 1987; Udvardy 1998; Howard et al. 2004) due to cultivations for ornamental, productive and erosion control purposes (Hu 1979; Udvardy 1998; Kowarik and Säumel 2007; Badalamenti et al. 2012). Its first record for the Ital-

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ian territory dates back to 1760 in the Botanical Garden of Padua (Badalamenti et al. 2012). Now is present in all the Italian administrative regions (Galasso et al. 2018) classified as invasive alien species because it can constitute proper forest communities (Montecchiari et al. 2020b; Viciani et al. 2020) capable to impact native ecosystems and Natura 2000 sites (Lazzaro et al. 2020). Moreover, according to the National Forest Inventory (Tabacchi et al. 2007), which classifies in a single category the *A. altissima* and *R. pseudoacacia* and forests, these formations together occupy almost 250000 ha, equal to 2.23% of the total national wooded area.

The efficacy in gamic reproduction and dissemination (Knapp and Canham 2000; Motard et al. 2011), agamic reproduction (Kowarik 1995; Kowarik and Saumel 2007, Von der Lippe et al. 2013) and rapid growth, enable *A. altissima* to form nearly pure stands (Dihoru and Doniţă 1970; Montecchiari et al. 2020b) and to have better competitive ability compared to the forest native species (Arnaboldi et al. 2002; Fotiadis et al. 2011; Höfle et al. 2014; Costàn-Nava et al. 2015). Moreover, the production of an allelopathic compound (Ailanthone) from the bark and leaves, can inhibit the germination of native species (Lawrence et al. 1991; Bostan et al. 2014). It shows a high tolerance to limiting ecological factors such as soil type and drought with several adaptations to water loss (Kowarik and Saumel 2007; Sladonja et al. 2015). *A. altissima* is better adapted to warmer climate regimes, in fact, it shows a high susceptibility to cold that is a limiting factor for the sapling survival (von der Lippe et al. 2005). Badalamenti et al. (2012) reports that *A. altissima* avoids excessively clay soils or soils subject to prolonged water stagnation. Thanks to its highly competitive features *A. altissima* can establish in a wide variety of environmental conditions and is able to form dense forest population that can also impact soil properties and nutrient cycling (Vilà et al. 2006; Gómez-Aparicio et al. 2008; Castro-Díez et al. 2009; Medina-Villar et al. 2015; Motard et al. 2015; Montecchiari et al. 2020b). Despite the many ecological data available and its wide distribution in the Mediterranean and Temperate Europe, there is an important lack of floristic-vegetational studies on *A. altissima* forests in its meridional range of distribution, in sub-Mediterranean and Mediterranean areas. From a syntaxonomic point of view, in Europe is recognized only one class (with two orders and three alliances) that comprehends alien tree species as characteristic species: the *Robinietea* class. It includes "seral forest-clearing and anthropogenic successional scrub and thickets on nutrient-rich soils of temperate Europe" (Mucina et al. 2016) but it includes also thermophilus and xerophilous communities such as those of the *Euphorbio cyparissiae-Robinietalia* order defined as "tortuous and xerophilous Black Locust stands of thermophilus habitats" and on poor soils" (Vitkova and Kolbek 2010). Recently in Allegrezza et al. (2019) was described the *Lauro nobilis-Robinion pseudoacaciae* alliance for the peri-Adriatic sector of Central Italy, that brings together forest and pre–forest coenoses dominated by *R. pseudoacacia* that include forests communities dominated by other invasive alien tree species that have developed in the Mediterranean macroclimate territories of central and southern Italy that also extend into the temperate macroclimate of the sub-Mediterranean variant. Currently, in literature, there is only one *A. altissima* syntaxon, described for est-Romania by Sîrbu & Oprea (2010) called *Balloto nigrae-Ailanthetum altissimae*. This association is referred to the *Balloto nigrae-Robinion pseudoacaciae* alliance, *Chelidonio-Robinietalia pseudoacaciae* order *Robinietea* class. The association comprehend *A. altissima* communities situated between 38 and 265 m a.s.l. near human settlements, along roadsides-railway embankments, in abandoned agricultural areas and on the edge of *Robinia pseudoacacia* plantations that comprehends "heliophilous (sub-heliophilous), moderate thermophilous, xero-mesophilous, neutrophilous and moderate nitrophilous phytocoenoses" (Sirbu & Oprea 2010). Also, *A. altissima* communities of Slovakia were referred to *Balloto nigrae-Ailanthetum* association by Valachovic (2018). For central-Europe, there are other published floristic-vegetation data of *A. altissima* coenoses but described only at the community level. Those communities have been described without a clear syntaxonomical classification and referred to syntaxonomic classes other than the *Robinietea* class such as *Sisymbrietea*, *Chenopodietea*, *Artemisietea*, *Agropyretea* or *Urtico-Sambucetea*, *Cratego-Prunetea*, *Quercetea pubescenti–petraeae* classes (Gutte et al. 1987) or described as *Ailanthus*-woods with *R. pseudoacacia* and *Acer* species with a non-clear syntaxonomic attribution (Kowarik and Bocker 1984). Moreover, for the Mediterranean region, Kowarik (1983) reported on the colonization by the *A. altissima* in the French-Mediterranean region classifying the *A. altissima* communities according to the Hemeroby classification system. He reported only one relevè "the only *A. altissima* occurrence in a non-ruderalized *Quercion ilicis* stand is on the northern slope of the mountain range".

In literature is also cited *A. altissima* associations with no floristic-vegetational data linked to this syntaxons in literature such as *Ailantho altissimae-Robinietum pseudacaciae* Julve 2003 referred to *Robinio pseudoacaciae-Ulmion minoris* Julve 1993 alliance, *Pruno avium-Carpinetalia betuli* Gillet 1986 ex Julve 1993 order, *Fraxino excelsioris-Quercetea roboris* Gillet 1986 ex Julve 1993 class and the *Fico-Ailanthetum altissimae* Lov. (1975) 1984 ("*Ailantho-Robinietum*" auct. adriat. Pp non Gutte; Kvarner: "žiròvine").

For the Italian territory, there are only two published papers that describe *A. altissima* dominated vegetation: Fanelli (2002) described *A. altissima* forest community for the surroundings of the city of Rome and Sciandrello et al. (2017) described a *Rubus ulmifolius* shrub community in Sicily (*Pruno spinosae-Rubion ulmifolii*, *Pyro spinosae-Rubetalia ulmifolii*, *Crataego-Prunetea*) with *A. altissima* having cover–abundance values higher than 3 (Braun-Blanquet scale) in four relevés. In the present paper, we aimed to describe the structure, ecology and syn-

taxonomy of the *A. altissima* forest communities present in its southern limit of presence in Europe. Specifically, the aims of this syntaxonomic study are to i) extend the poor floristic-vegetational data available for *A. altissima* forests communities in the Italian peninsula; ii) define the *A. altissima* forest vegetational types at the community level and the ecological and landscape context in which they are found; iii) highlight the possible floristic-vegetational autonomy of these coenoses in the context of the *Robinietea* class in comparison with *A. altissima* floristic-vegetational data from Europe.

Study area

The study was conducted in central Italy (Marche-Abruzzo peri-Adriatic sector) (Figure 1) at altitudes that range from 10 m a.s.l. to 500 m a.s.l on pelitic-arenaceous, arenaceous-pelitic and alluvial lithotypes. The bioclimatic classification sensu Rivas-Martínez et al. (2011) for these territories indicates a Macrobioclimate that ranging from Mediterranean, pluviseasonal oceanic bioclimate and upper meso-Mediterranean thermotype to the Temperate sub-Mediterranean variant, oceanic bioclimate and lower meso-temperate thermotype (Pesaresi et al. 2014) according to the bioclimatic classification. The prevailing land use categories are mostly cops such as heterogeneous agricultural areas with complex cultivation patterns and non-irrigated arable land. The native forests vegetation consists of *Quercus pubescens*/*Q. virgiliana* woods on slopes referred to the alliance *Carpinion orientalis* (class *Querco roboris-Fagetea sylvaticae*), and riparian woods of *Salix alba* and *Populus nigra* referred to the alliance *Populion albae* (class *Salici purpureae-Populetea nigrae*). The high-shrub pre-forest vegetation is represented by *Ulmus minor* communities of the *Lauro nobilis-Ulmion minoris* alliance (class *Salici purpureae-Populetea nigrae*) (Blasi et al. 2010).

Materials and Methods

The study of the plant communities was carried out according to the phytosociological methods of the Zurich–Montpellier school (Braun-Blanquet 1928), updated according to the most recent acquisitions (Rivas-Martínez 2005; Allegrezza et al. 2008; Biondi 2011; Blasi and Frondoni 2011). We performed a total of 22 unpublished phytosociological relevés. The surveys were performed on *A. altissima* forests aged >20 years, where the alien tree was clearly dominant and over a minimum homogeneous area of 100 m². For the characterization of the *A. altissima* forests of the Italian peninsula, the unpublished relevés were analyzed along with 5 relevés from Fanelli (2002) that

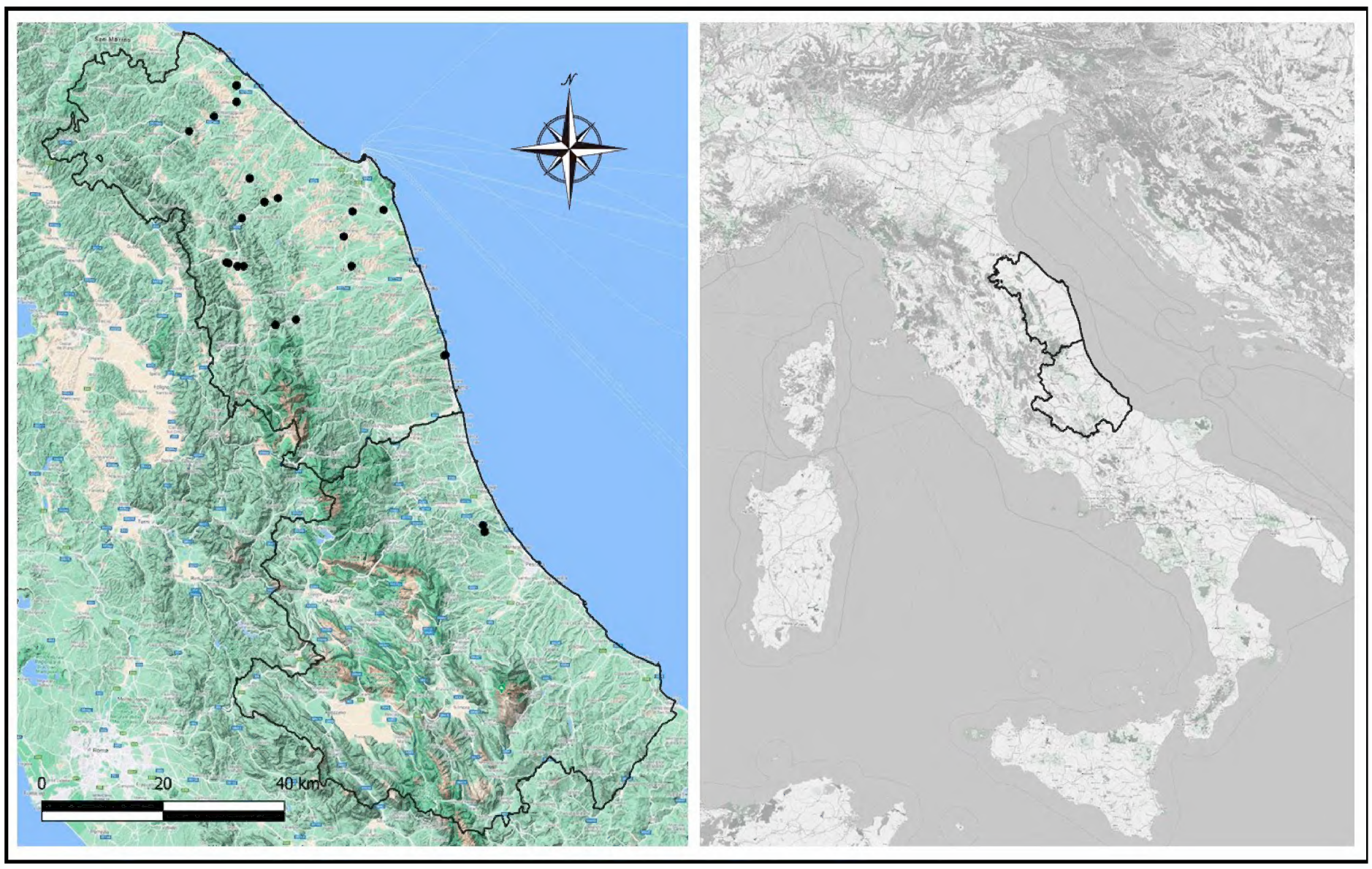

Figure 1. Study area. Location of the study area showing the distribution of the unpublished relevés. Each relevè is represented by a single black point.

described *A. altissima* community for the surrounding of Rome, because they have a forest structure, with clearly dominant *A. altissima*, having cover-abundance values higher than 3 (Braun-Blanquet scale) (see Appendix II). For the comparisons between the Italian peninsula and the European context we selected literature data that have been attributed to a syntaxon that includes *A. altissima* in the name and clearly dominant (cover-abundance values >3). Were used a total of 25 phytosociological relevés referred to the *Balloto nigrae-Ailanthetum altissimae* association respectively 20 from Sirbu & Oprea (2010) 5 from Valachovic (2018). The nomenclature of the species follows the check-list of Italian flora (Bartolucci et al. 2018). The life forms and chorology of the species follow Flora d'Italia (Pignatti et al. 2017–2019). For the Ellenberg indicators values (EIVs) (Ellenberg et al. 1992), we used the indices reformulated for the Mediterranean conditions (Pignatti et al. 2005): L light, T temperatures, C continentality; U soil moisture, R soil reaction, N availability of soil nutrients. The syntaxonomic classification is made according to the Prodrome of the Italian Vegetation (Biondi et al. 2014), as present on the updated site of the Italian Botanical Society (http://www. prodromovegetazioneitalia.org/), with references to that of the European vegetation (Mucina et al. 2016). The status of alien species (specifying between Archeophytes and Neophytes) has been assigned according to Galasso et al. (2018) and information on the national floras for the European data.

Data analysis

The vegetation data were processed using the "vegan" package (Oksanen et al. 2020) of the R software (R core team 2018). The cover–abundance values of the phytosociological matrix were converted to the Van der Maarel (1979) decimal scale and subjected to multivariate analysis. Before calculations, the ecological variables matrix was undergone at a normalization process using the "decostand" function on the "vegan" package. The numerical classification according to cluster analysis was carried out by applying the "Ward" link algorithm to the similarity ratio matrix calculated by applying the "Jaccard" index on the vegetation matrix converted in presence/absence values. Life forms of each relevè were weighted on the species abundance values and then averaged at the group level. To compare EIVs of the plots, we used weighted average values. Box plot diagrams were used to illustrate data distribution of Life forms and EIVs. To analyze the variance of the groups and tests for significance we used ANOVA (supplementary materials, Table S1) ("aov" function of "stats" package). The Shapiro test was used to test the normality of the analyzed data and the Bartlett test for homoscedasticity.

For the comparison with the published European data, we create a unique phytosociological matrix, converted to the Van der Maarel (1979) decimal scale and subjected to multivariate analysis. The similarity matrix obtained applying the "Jaccard" index was used to perform non–metric multidimensional (NMDS) ordination diagram. The NMDS ordination diagram is suitable for the analysis of ordinal data such as those of Van der Maarel (Podani 2007) and was used to describe the main trends of the vegetation variations. Percentage weighted presence of chorological types and alien species for each plot was calculated and illustrated by box plots. Then we performed the analysis of variance and tested the significance among the averages of the identified groups.

Results and Discussion

The dendrogram (Fig. 2a) obtained from the classification of phytosociological relevès highlights two main groups (Cluster I and Cluster II) which correspond to the two main structural, ecological and floristic–vegetational characteristics of the *A. altissima* forest communities. The comparison of the statistically significant traits such as functional (life forms) and ecological traits (EIVs), highlights the structural and ecological differences between the two groups. The first group (Cluster I) differs for the higher coverage of phanerophytes (Fig. 2b.2) and thermophilous species (Temperature EIV) (Fig. 2b.4) while the second group (Cluster II) is characterized by the higher coverage of herbaceous species such as Geophytes and Terophytes (Fig. 2b.1 and 2b.3). The processing of the relevès in Table 1 and the comparison with the similar phytocoenoses described for south–est Europe allows us to propose and describe two new associations of *A. altissima* forest vegetation within the sub– Mediterranean alliance *Lauro nobilis-Robinion pseudoacaciae* (order *Chelidonio-Robinietalia pseudoacaciae* and class *Robinietea*): *Asparago acutifolii-Ailanthetum altissimae* (cluster I) and *Aro italici-Ailanthetum altissimae* (Cluster II).

ASPARAGO ACUTIFOLII–AILANTHETUM ALTISSIMAE ass. nova (Cluster I Fig. 2; *typus* rel. 7 of Tab. 1)

It is a sub-Mediterranean and Mediterranean forest community dominated by *A. altissima* characterized by a stratified structure and high canopy density, with an average height of 13.6 and an average richness of 16 species per relevè. It is typically present on the warmer slopes of the hills (up to 460 m a.s.l.) with arenaceous-pelitic, arenaceous and locally calcareous substrates, in dry soil conditions and in areas subject to low anthropic disturbance (the surrounding landscape is characterized by the greater presence of forest areas). In the dominated tree and shrub layer are frequent forest species of the *Querco-Fagetea* class such as *Hedera helix*, *Acer campestre*, *Quercus pubescens*, *Fraxinus ornus* and pre-forest and shrub species of the *Rhamno-Prunetea* class such as *Rubus ulmifolius*, *Clematis vitalba*, *Ulmus minor*. Those species indicate that the potential native vegetation for the territory occupied by the *A. altissima* forest of the *Asparago acutifolii-Ailanthetum altissimae* is the Mediterranean and sub-Mediterranean oak forests of the *Carpinion orientalis* alliance, re-

ferring to the habitat of community interest 91AA (92/43/EEC Habitats Directive). Characteristic and differential species of the new association are *A. altissima*, *Hedera helix*, *Acer campestre*, *Quercus pubescens*, *Fraxinus ornus*, *Prunus spinosa, Asparagus acutifolius* and *Olea europaea*. The new association refers to the *Lauro nobilis-Robinion pseudoacaciae* alliance because of the presence of characteristic species of this syntaxon such as *Rubus ulmifolius*, *Laurus nobilis*, *Melissa officinalis* subsp. *altissima*, *Rubia peregrina*, *Parietaria diffusa*, *Viola alba* subsp. *dehnhardtii*, *Ficus carica*, *Ligustrum vulgare*, *Rosa sempervirens*, *Rhamnus alaternus*, *Avena barbata*, etc. The characteristic species of the order *Chelidonio-Robinetalia pseudoacaciae* and *Robinietea* class except for *A. altissima* (*Robinietea* class) are present locally and with low coverage values especially in the xerophilous aspects similarly to what happens for the thermophilous communities of the association *Rubio peregrinae-Robinietum pseudoacaciae* (Allegrezza et al. 2019). However, as highlighted in Allegrezza et al. (2019), the *Lauro nobilis-Robinion pseudoacaciae* alliance includes, in addition to the typically nitrophilous aspects on soils rich in organic matter, also xerophilous

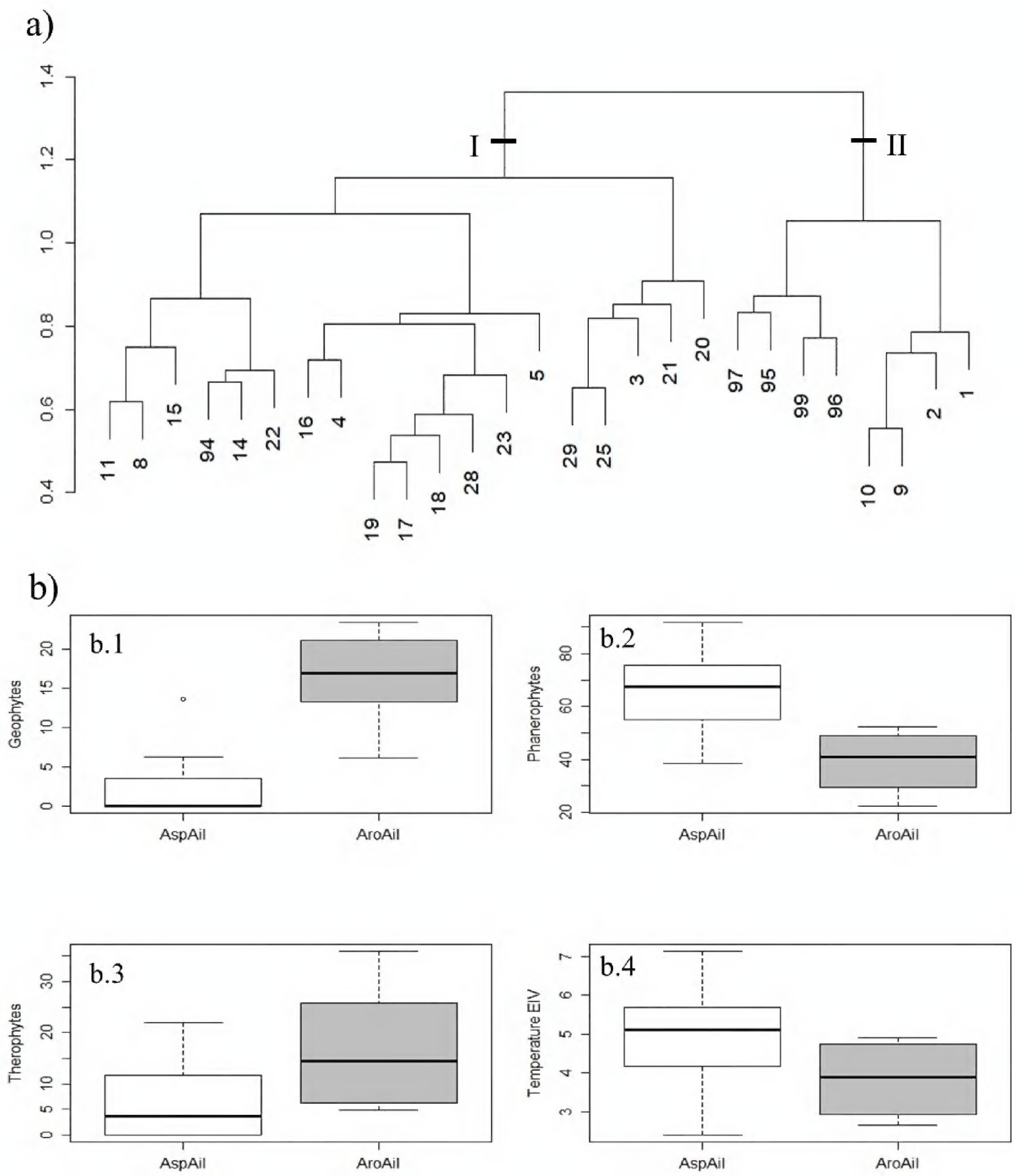

Figure 2. Classification of the Italian *A. altissima* forest communities and box plots of the life forms. (a) Dendrogram from the phytosociological relevés of the *A. altissima* communities in the study area and published relevés from Fanelli (2002). Cluster I, *Asparago acutifolii-Ailanthetum altissimae*; Cluster II, *Aro italici-Ailanthetum altissimae*. (b) Comparison of the significant life form and EIVs of the two *A. altissima* forest associations (AspAil: *Asparago acutifolii-Ailanthetum altissimae* and AroAil: *Aro italici-Ailanthetum altissimae*) through box plots. (b.1) Geophytes p value <0,0001, (b.2) Phanerophytes p value <0,0001; (b.3) Terophytes p value = 0.001; (b.4) Temperature EIV p value =0.04.

Table 1. Mediterranean and sub-Mediterranean *A. altissima* forest communities belong to the alliance *Lauro nobilis-Robinion pseudoacaciae*. *Asparago acutifolii-Ailanthetum altissimae* ass. nova (rels 1–19, *typus* rel. 7); *Aro italici-Ailanthetum altissimae* ass. nova (rels 20–27, *typus* rel. 22).

Life form																														
	N° rel.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27			
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13	Pres.	Freq. Gr. I	Freq. Gr. II
	***Asparago acutifolii-Ailanthetum altissimae* ass. nova**																														
P lian	*Hedera helix* L.	3.3	1.1			3.3	2.2	4.4	2.2	4.4	5.5	4.4	2.3	+.2	+		3.3	4	+	+		1.2		1.1					18	V	II
P scap	*Acer campestre* L.			+			+		1.1	2.2	2.2	+	+	+	+	+				1.2									11	III	
P caesp	*Quercus pubescens* s.l. Willd.	+		+	+			+					+	1.1					2.2	1.2									8	III	
P scap	*Fraxinus ornus* L.	+		+		1.1		+				+																	5	II	
G rhiz	*Asparagus acutifolius* L.	1.1	+		2.3	1.1	1.1	+	1.1				+										+				+		10	II	II
P caesp	*Prunus spinosa* L.					1.1	+	+	+	+	+	+					1.1												8	III	
P caesp	*Olea europaea* L.			+	+.2										+				+	+									5	II	
	***Aro italici-Ailanthetum altissimae* ass. nova**																														
G rhiz	*Arum italicum* Mill.																+				1.2	1.2	1.1	3.3	1	+	+	+	9	I	V
G rhiz	*Elymus repens* (L.) Gould subsp. *repens*																				1.2	1.2	3.3						3		III
G rhiz	*Convolvulus arvensis* L.																				+	+		+					3		III
H caesp	*Poa trivialis* L.						+																			+	+	+	4	I	III
	Lauro nobilis-Robinion pseudoacaciae																														
NP	*Rubus ulmifolius* Schott	1.1	+		+	2.2	+	2.2	2.2	+	+	1.1	2.3	1.1		5.5	+	+	+		3.3	+.2	+.2		+	+			21	V	IV
P caesp	*Laurus nobilis* L.	+		+				1.1	+		1.1				+	+	+	2	+			1.2				+			12	III	II
H scap	*Melissa officinalis* subsp. *altissima*	+					+		+			+		+	+					1.1	1.2	+.2	2.2						10	II	III
P lian	*Rubia peregrina* L.	+			+	+		2.2					2.2														1		6	II	I
H scap	*Parietaria diffusa* M. et K.				+								+					+					+.2	+				1	6	I	III
T scap	*Anisantha diandra* (Roth) Tutin ex Tzvelev	1.1	1.1		+																1.2		1.1						5	I	II
T scap	*Avena barbata* Potter				+		2.2																+	1.1		+			5	I	III
H ros	*Viola alba* Besser subsp. *dehnhardtii* (Ten.) W.Becker							+		+				+								+.2							4	I	I
P scap	*Ficus carica* L.																			+.2		1.2		+					3	I	II
NP	*Ligustrum vulgare* L.								+	2.2				2															3	I	
P caesp	*Rhamnus alaternus* L.				1.2								1.1														1		3	I	I
H caesp	*Brachypodium rupestre* (Host) R. et S.			+										+															2	I	
G bulb	*Bellevalia romana* (L.) Sweet			+																									1	I	
P scap	*Juglans regia* L.							+																1.1					2	I	I

Table 1. Continuation.

Life form	N° rel.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27	Pres.	Freq. Gr. I	Freq. Gr. II
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13			
NP	*Rosa sempervirens* L.							+																			+		2	I	I
H bienn	*Inula conyzae* (Griess.) DC.			+																									1	I	
P scap	*Quercus ilex* L.					+																							1	I	
G rhiz	*Ruscus aculeatus* L.							+																					1	I	
G rhiz	*Arundo plinii* Turra												+.3																1	I	
G rhiz	*Chamaeiris foetidissima* (L.) Medik.																	+											1	I	
T scap	*Sinapis alba* L.																						+.2						1		I
	***Chelidonio-Robinietalia* and** *Robinietea*																														
P scap	*Ailanthus altissima* (Mill.) Swingle	4.4	3.3	3.3	4.4	4.4	5.5	3.3	4.4	4.4	5.5	4.4	4.4	5.5	4.4	4.4	4.4	5	4.4	4.5	4.4	4.4	4.4	4.4	4	5	5	5	27	V	V
P caesp	*Sambucus nigra* L.						+	+				3.3	+	2.2			+	+	2.2					+					9	III	I
T scap	*Galium aparine* L.																		+	1.1		+.2		2.2	4	+	+	1	8	I	IV
H scap	*Urtica dioica* L.											+					+	+	+	+	+.2	+			2				8	II	III
P caesp	*Robinia pseudoacacia* L.							1.1	+			+	1.1										+	+.2	1				7	II	III
T scap	*Chaerophyllum temulum* L.						3.3	+				+			+		+			+-2									6	II	
T scap	*Anisantha sterilis* (L.) Nevski														+			+		+					1			2	5	I	II
H bienn	*Alliaria petiolata* (M.Bieb.) Cavara & Grande						+									+	+								+				4	I	I
H scap	*Lamium maculatum* L.									+	+	+		+															4	II	
H caesp	*Dactylis glomerata* L.		+		+															+.2									3	I	
H scap	*Geum urbanum* L.						+																						1	I	
T rept	*Stellaria media* (L.) Vill.																											+	1		I
H scap	*Ballota nigra* L.																							1.1					1		I
G rhiz	*Bryonia dioica* Jacq.																											1	1		I
T scap	*Fallopia convolvulus* (L.) Holub																								+				1		I
H scap	*Anthriscus sylvestris* (L.) Hoffm.																									+			1		I
	Others																														
P lian	*Clematis vitalba* L.	+		+		+		+	+	+	3.3	+	1.1	1.1	+	+		+	+	3.3	1.2	+.2	+	1.1					19	IV	III
P caesp	*Crataegus monogyna* Jacq.	+	+				+	+	+	1.1	+	+		+	+								+				+		12	III	II
P scap	*Prunus avium* (L.) L.							+			+	+		1.1															4	II	
P caesp	*Cornus sanguinea* L.							+	+	+	1.1	2.2	+	1.1					+	+.2	1.2						+		11	III	II
P caesp	*Ulmus minor* Miller										+		+	+	2.2	+	2.2	+		1.2								+	9	III	I

Table 1. Continuation.

Life form																																
	N° rel.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18	19	20	22^	21	23	24	25	26	27			
	N° rel. from dendrogram fig. 2	29	25	20	3	21	5	23	28	18	17	19	4	16	15	22	14	94	8	11	9	10	2	1	97	96	99	95			
	N° cluster from dendrogram fig. 2	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II			
	Altitude [m o.s.l.]	114	38	310	97	462	28	162	80	308	359	268	40	301	140	179	50		152	460	114	97	330	350							
	Aspect	S	SE	S	S	E	NO	NE	E	E	NE	N	SO	NO	SE	NO	SE	SO	NO	O	O	E	SE	S	O	SE	O	NO			
	Slope [°]	30	10	15	30	15	20	25	35	5	15	15	20	15	15	10	10	5	35	40	-	-	5	25	45	2	1	15			
	Area [mq]	200	100	100	90	400	350	250	250	100	100	250	150	100	250	150	300	100	150	120	200	200	100	150	80	80	80	50			
	Total cover [%]	90	90	90	90	85	97	95	90	90	100	95	90	95	99	85	95		98	95	95	50	100	90							
	Tree layer height [m]	8	13	19	8.3	10	19	20	14	11	12	20	9	13	13	8	14	20	15.8	11.4	14	8	10.5	8	15	20	15	7			
	N° species x rel.	17	14	19	18	16	22	23	16	15	12	17	16	25	17	7	13	14	12	17	12	14	15	14	15	11	16	13	Pres.	Freq. Gr. I	Freq. Gr. II
P caesp	*Euonymus europaeus* L.	1.1	+	+			1.1	+		+		1.1			+						+.2								9	III	I
H scap	*Clinopodium nepeta* (L.) Kuntze		+		+									1.1						+.3									4	II	
P caesp	*Paliurus spina christi* Miller		1.1	+					+																				3	I	
H scap	*Galium album* Miller	+	+											+															3	I	
H caesp	*Brachypodium sylvaticum* (Huds.) Beauv.					5.5			1.1																		+		3	I	I
P scap	*Cercis siliquastrum* L.	+		1.1																									2	I	
NP	*Rubus caesius* L.	1.1																									+		2	I	I
H scap	*Picris hieracioides* L.		+											+															2	I	
NP	*Osyris alba* L.			+		+																							2	I	
T scap	*Torilis arvensis* (Hudson) Link		1.1												+														2	I	
H scap	*Rumex obtusifolius* L.																										+	+	2		II
P caesp	*Prunus domestica* L.						+		+																				2	I	
NP	*Rosa canina* L.					1.1								+															2	I	
H scap	*Cruciata glabra* (L.) Ehrend.						+.2							+															2	I	
H ros	*Silene italica* (L.) Pers.						+										+												2	I	
H caesp	*Carex pendula* Huds.									+												+							2	I	I
P lian	*Lonicera japonica* Thunb.												3.2														1		2	I	I
G rhiz	*Arundo donax* L.						+																	+					2	I	I
H bienn	*Silene latifolia* Poiret													+											+				2	I	I
H scap	*Stachys sylvatica* L.																+											+	2	I	I
P scap	*Populus nigra* L.									+											+.2								2	I	I
	Sporadics species	1	1	5	6	4	3	2	-	1	-	-	-	3	4	-	1	2	1	1	-	-	2	-	5	2	2	3			

and thermophilous communities on dry soils in poorly anthropized contexts (Allegrezza et al. 2019).

Compared to the *Rubio peregrinae-Robinietum pseudoacaciae* association described by Allegrezza et al. (2019) for the same study area, the floristic composition of the new association *Asparago acutifolii-Ailanthetum altissimae* essentially differs for the lower species richness and coverage of mesophilous and nitrophilous species such as *Sambucus nigra* denoting for the *A. altissima* forests a stronger thermophilous and xerophilous character, in accordance with what is reported in the literature on the ecology of *A. altissima* (e.g. Sladonja et al. 2015).

ARO ITALICI–AILANTHETUM ALTISSIMAE ass. nova (Cluster II Fig. 2; *typus* rel. 22 of Tab. 1).

The new association refers to the *A. altissima* sub-Mediterranean and Mediterranean paucispecific forest communities characterized by a monolayered structure, with a with an average height of 12 m, and an average richness of 13 species per relevè. These forest coenoses are typically found in agricultural areas in correspondence with pelitic, alluvial silty-sandy substrates and peri-urban areas in conditions of edaphic humidity and high anthropogenic disturbance. The shrub layer is poor in species and it consists exclusively of *Rubus ulmifolius* and *Clematis vitalba*, even if locally can be also found *Laurus nobilis* and *Robinia pseudoacacia*. On the other hand, the herbaceous layer is locally rich in species and characterized by geophytes and transgressive hemicriptophytes of the *Galio-Urticetea* classes (*Galium aparine*, *Arum italicum*), *Artemisietea* (*Elymus repens*, *Poa trivialis*), *Robinietea* and terophytes of the *Stellarieta mediae* class (*Anisantha diandra*, *Avena barbata*) which highlight the conditions of high and constant anthropogenic disturbance. Characteristic and differential species of the new association are *A. altissima*, *Arum italicum*, *Elymus repens*, *Convolvulus arvensis* and *Poa trivialis*. The new association *Aro italici-Ailanthetum altissimae* that is referred to the *Lauro nobilis-Robinion pseudoacaciae* alliance (*Chelidonio-Robinietalia pseudoacaciae* order and *Robinietea* class) has floristic analogies with the *R. pseudoacacia* association *Melisso altissimae-Robinetum pseudoacaciae* widely present on alluvial plains of the Mediterranean and sub-Mediterranean region. The main differences between these two association are that the *Aro italici-Ailanthetum altissimae* is less common in the study area and has an extremely impoverished tree and shrub components. Furthermore, even if the *Robinia* forest vegetation is also found in the position of the willow groves of *Salix alba* (*Melisso altissimae-Robinietum pseudoacaciae* var. *Carex pendula*), in the investigated territories, the *A. altissima* forest vegetation is almost absent in this landscape context. This confirms what is reported in the literature on the ecology of *A. altissima* that does not tolerate prolonged conditions of soil water stagnation (e.g. Badalamenti et al. 2012).

Comparison of *A. altissima* communities in Europe and in the Mediterranean and sub–Mediterranean areas

The NMDS ordination plot (Fig. 3a) of the *A. altissima* forest coenoses here considered along with those from SE-Europe, highlights the separation into two distinct groups. The first group corresponds to the two new associations here proposed: *Asparago acutifolii–Ailanthetum altissimae* and *Aro italici-Ailanthetum altissimae* of the sub-Mediterranean and Mediterranean alliance *Lauro nobilis-Robinion pseudoacaciae*, while the second group corresponds to the *Balloto nigrae-Ailanthetum altissimae* association of the *Balloto nigrae-Robinion pseudoacaciae* alliance with a south-eastern European range. The floristic differentiation between the two groups is mainly determined by the syn-chorology. The statistically significant chorological elements (Fig. 3b) were the Mediterranean and Boreal chorotypes and the weighted presence of naturalized (archaeophytes) and invasive (neophytes) species. The Mediterranean chorotype (Fig. 3b.1) is linked to the syntaxa of the *Lauro nobilis-Robinion pseudoacaciae* alliance while the Boreal chorotype (Fig. 3b.2) and the presence of archeophyte and neophyte alien species (Fig. 3b.4) characterize the *Balloto nigrae-Ailanthetum altissimae* association of the *Balloto nigrae-Robinion pseudoacaciae* alliance. As can be seen in the Synoptic table reported in Table 2, the *Lauro nobilis-Robinion pseudoacaciae* alliance recently described for the sub-Mediterranean and Mediterranean forest communities of *Robinia pseudoacacia* confirms its floristic autonomy with respect to the analogous coenoses described for the center and SE–Europe, also for the *A. altissima* forest coenoses present at their southern limit of distribution in Europe. Even if not considered in the data processing of this work (not forest structure), the shrub communities of *A. altissima* and *Rubus ulmifolius* found in Sicily (Sciandrello et al. 2016) can also be referred to the same alliance. The *Lauro nobilis-Robinion pseudoacaciaciae* alliance could also be extended to *A. altissima* forest communities present in the Mediterranean and sub-Mediterranean areas of France. It can be done thanks to the only phytosociological relevè reported in Kowarik (1983) in which *A. altissima* communities with *Quercus ilex* of the territory of Collies (South France) shows floristic and ecological analogies with the more xerophilic elements of the *Asparago acutifolii-Ailanthetum altissimae* here proposed. At the landscape level, the sub-Mediterranean and Mediterranean *A. altissima* forest communities are mainly found in the forest landscape of the order *Quercetalia pubescentis-petraeae* with the alliances *Carpinion orientalis* and locally with those of *Quercetea ilicis* for the more xerophilic aspects. As regards the relationships with the similar sub-Mediterranean *R. pseudoacacia* of forest coenoses of the *Lauro nobilis-Robinion pseudoacaciae* alliance described above:

Table 2. Synoptic table of *A. altissima* communities in Europe. *Asparago acutifolii-Ailanthetum altissimae* ass. nova (column 1); *Aro italici-Ailanthetum altissimae* ass. nova (column 2); *Balloto nigrae-Ailanthetum altissimae* (column 3).

Life form	Chorotype	N. columns	1	2	3	Pres.
		N. rels. per column	19	8	25	
		***Asparago acutifolii-Ailanthetum altissimae* ass. nova**				
P lian	Eur./SW-Asiat.	*Hedera helix* L.	V	II	.	2
G rhiz	Medit.	*Asparagus acutifolius* L.	II	II	.	2
P caesp	S-Eur.	*Quercus pubescens* Willd.	III	.	.	1
P caesp	Medit.	*Olea europaea* L.	II	.	.	1
P scap	S-Eur./W-Asiat.	*Fraxinus ornus* L.	II	.	.	1
P caesp	Eur./W-Asiat.	*Prunus spinosa* L.	III	.	I	2
P scap	Eur./W-Asiat.	*Acer campestre* L.	III	.	I	2
		***Aro italici-Ailanthetum altissimae* ass. nova**				
G rhiz	Medit.	*Arum italicum* Miller	I	V	.	2
G rhiz	Circumbor.	*Elymus repens* (L.) Gould subsp. *repens*		III	V	2
G rhiz	S-Eur./W-Asiat.	*Convolvulus arvensis* L.		III	I	2
H caesp	Eurasiat./N-Am.	*Poa trivialis* L.	I	III	I	3
		Lauro nobilis-Robinion pseudoacaciae				
NP	Euri-Medit. Eur.	*Rubus ulmifolius* Schott	V	IV	.	2
P caesp	Medit.	*Laurus nobilis* L.	III	II	.	2
H scap	Steno-Medit.	*Melissa officinalis* subsp. *altissima*	II	III	.	2
P lian	W-Eur./Medit.	*Rubia peregrina* L.	II	I	.	2
H scap	W-Eur./Medit.	*Parietaria diffusa* M. et K.	I	III	.	2
T scap	Medit.	*Anisantha diandra* (Roth) Tutin ex Tzvelev	I	II	.	2
T scap	Medit./SW-Asiat.	*Avena barbata* Potter	I	III	.	2
H ros	Medit.	*Viola alba* Besser subsp. *dehnhardtii* (Ten.) W.Becker	I	I	.	2
P scap	Medit./SW-Asiat.	*Ficus carica* L.	I	II	.	2
P caesp	Medit.	*Rhamnus alaternus* L.	I	I	.	2
NP	Medit.	*Rosa sempervirens* L.	I	I	.	2
NP	Eur./W-Asiat.	*Ligustrum vulgare* L.	I	.	I	2
H caesp	Eur.	*Brachypodium rupestre* (Host) R. et S.	I	.	.	1
G bulb	Medit.	*Bellevalia romana* (L.) Sweet	I	.	.	1
P scap	SE-Eur./SW-Asiat.	*Juglans regia* L.	I	I	I	3
H bienn	Eurasiat./N-Afr.	*Inula conyzae* (Griess.) DC.	I	.	.	1
P scap	Medit.	*Quercus ilex* L.	I	.	.	1
G rhiz	Medit.	*Ruscus aculeatus* L.	I	.	.	1
G rhiz	Steno-Medit	*Arundo plinii* Turra	I	.	.	1
G rhiz	SW-Eur.	*Chamaeiris foetidissima* (L.) Medik.	I	.	.	1
T scap	Euri-Medit.	*Sinapis alba* L.		I	I	2
		Balloto nigrae-Ailanthetum altissimae* and *Balloto nigrae-Robinion pseudoacaciae				
T scap	Medit.	*Bromus sterilis* L.	I	II	IV	3
H caesp	Eurasiat.	*Dactylis glomerata* L.	I	.	I	2
H scap	Medit.	*Ballota nigra* L.	.	I	V	2
H bienn	S-Eur.	*Lactuca serriola* L.	.	.	II	1
H caesp	Circumbor.	*Poa angustifolia* L.	.	.	I	1
H caesp	Paleotemp.	*Arrhenatherum elatius* (L.) Presl.	.	.	I	1
H caesp	Eurosib.	*Calamagrostis epigejos* (L.) Roth	.	.	I	1
H bienn	Eurasiat.	*Cynoglossum officinale* L.	.	.	I	1
H scap	Circumbor.	*Artemisia vulgaris* L.	.	.	III	1
H bienn	Eurasiat.	*Arctium lappa* L.	.	.	II	1
H scap	A. Nat.	*Leonurus cardiaca* L.	.	.	II	1
Ch rept	Circumbor.	*Glechoma hederacea* L.	.	.	II	1
NP	N. Nat.	*Lycium barbarum* L.	.	.	I	1
Ch suffr	Sub-Cosmop.	*Artemisia absinthium* L.	.	.	II	1
T scap	Circumbor.	*Atriplex patula* L.	.	.	II	1
G rhiz	Medit.	*Sambucus ebulus* L.	.	.	II	1
H scap	Eur.	*Parietaria officinalis* L.	.	.	I	1
H scap	N. Inv.	*Solidago canadensis* L.	.	.	I	1

Table 2. Continuation.

Life form	Chorotype	N. columns N. rels. per column	1 19	2 8	3 25	Pres.
		***Chelidonio-Robinietalia pseudoacaciae* and** *Robinietea*				
P scap	N. Inv.	*Ailanthus altissima* (Mill.) Swingle	V	V	V	3
P caesp	Eur.	*Sambucus nigra* L.	III	I	I	3
T scap	Eurasiat.	Galium aparine L.	I	IV	III	3
H scap	Subcosmop.	Urtica dioica L.	II	III	III	3
P caesp	N-Am.	Robinia pseudoacacia L.	II	III	II	3
H bienn	Eur./W-Asiat.	Alliaria petiolata (M.Bieb.) Cavara & Grande	I	I	I	3
T scap	Eur.	Chaerophyllum temulum L.	II	.	I	2
H scap	Eur./W-Asiat.	Lamium maculatum L.	II	.	.	1
P lian	Eur.	Humulus lupulus L.	.	.	II	1
H scap	Eurasiat.	Geum urbanum L.	I	.	II	2
T rept	Medit.	Stellaria media (L.) Vill.	.	I	I	2
T scap	Circumbor.	Fallopia convolvulus (L.) Holub	.	I	I	2
H scap	Paleotemp.	Anthriscus sylvestris (L.) Hoffm.	.	I	I	2
H scap	Medit.	Bryonia dioica Jacq.	.	I	.	1
G rhiz	N. Inv.	Impatiens parviflora DC.	.	.	I	1
H ros	Circumbor.	Taraxacum officinale Weber gr.	.	.	I	1
H scap	Eurasiat.	Chelidonium majus L.	.	.	I	1
H scap	Eurasiat.	Alkekengi officinarum Moench	.	.	I	1
P scap	N. Inv.	Acer negundo L.	.	.	I	1
T scap	Eurasiat.	Moehringia trinervia (L.) Clairv.	.	.	I	1
T scap	A. Nat.	Anthriscus cerefolium (L.) Hoffm.	.	.	I	1
P caesp	N. Nat.	Gleditsia triacanthos L.	.	.	I	1
P caesp	A. Nat.	Prunus cerasifera Ehrh.	.	.	I	1
H scap	N. Inv.	Solidago gigantea Aiton	.	.	I	1
		Others				
P lian	Eur.	Clematis vitalba L.	IV	III	II	3
P caesp	Eur./W-Asiat.	Crataegus monogyna Jacq.	III	II	I	3
P caesp	Eur.	Cornus sanguinea L.	III	II	I	3
P caesp	Eur.	Ulmus minor Miller	III	I	I	3
P caesp	Eur.	Euonymus europaeus L.	III	I	I	3
H caesp	Eurasiat.	Brachypodium sylvaticum (Huds.) Beauv.	I	I	I	3
NP	Eurasiat.	Rubus caesius L.	I	I	II	3
H scap	Eurosib.	Stachys sylvatica L.	I	I	I	3
H caesp	Eurasiat.	Carex pendula Huds.	I	I	.	2
P lian	N. Inv.	Lonicera japonica Thunb.	I	I	.	2
G rhiz	A. Inv.	Arundo donax L.	I	I	.	2
H bienn	Eurasiat.	Silene latifolia Poiret	I	I	.	2
P scap	Eurasiat.	Populus nigra L.	I	I	.	2
NP	Eur.	Rosa canina L.	I	.	II	2
H scap	Eurosib.	Picris hieracioides L.	I	.	I	2
T scap	Subcosmop.	Torilis arvensis (Hudson) Link	I	.	I	2
H bienn	Paleotemp.	Daucus carota L.	I	.	I	2
T scap	N. Inv.	Erigeron canadensis L.	I	.	I	2
H scap	Medit.	Galium mollugo L.	I	.	I	2
H scap	Circumbor.	Clinopodium vulgare L.	I	.	I	2
H scap	Eur.	Rumex obtusifolius L.	.	II	I	2
H scap	Paleotemp.	Conium maculatum L.	.	I	II	2
P scap	Eur./W-Asiat.	Prunus avium (L.) L.	II	.	.	1
H scap	Medit.	Clinopodium nepeta (L.) Kuntze	II	.	.	1
H scap	Subcosmop.	Agrimonia eupatoria L.	.	.	II	1
H bienne	Eur.	Carduus acanthoides L.	.	.	II	1
T scap	N. Inv.	Erigeron annuus (L.) Desf.	.	.	II	1
H scap	Eurasiat.	Tanacetum vulgare L.	.	.	II	1
T scap	Sub-Cosmop.	Chenopodium album L.	.	.	II	1
		Sporadic species	35	13	98	

Rubio peregrinae-Robinietum pseudoacaciae and *Melisso altissimae-Robinietum pseudoacaciae*, it is noted that the *A. altissima* forest vegetation is less widespread in the investigated territory but it prevails over *R. pseudoacacia* forests in the more xerophilous slope conditions on dry soil (*Asparago acutifolii-Ailanthetum altissimae*) while the *R. pseudoacacia* forest vegetation is mainly distributed along the river basins, on the recent alluvial loamy-sandy terraces and in the river beds (*Melisso altissimae-Robinietum pseudoacaciae*) where the *A. altissima* forests are almost absent. The distribution of *A. altissima* and *R. pseudoacacia* forests is mainly connected to the different ecology of the two dominant invasive alien species. As reported in the literature, *A. altissima* is a thermophilous species, adapted to edaphic aridity but it is limited by low temperatures and water stagnation (Kowarik 1983; Trifilò et al. 2004; Kowarik and Saumel 2007). As can be seen from the Table 2, the impoverishment of the species of the order *Chelidonio-Robinietalia* and the *Robinietea* class in the Mediterranean area mainly concerns the *A. altissima* communities present in the most xerophilous areas with low anthropic disturbance. However, this is similar

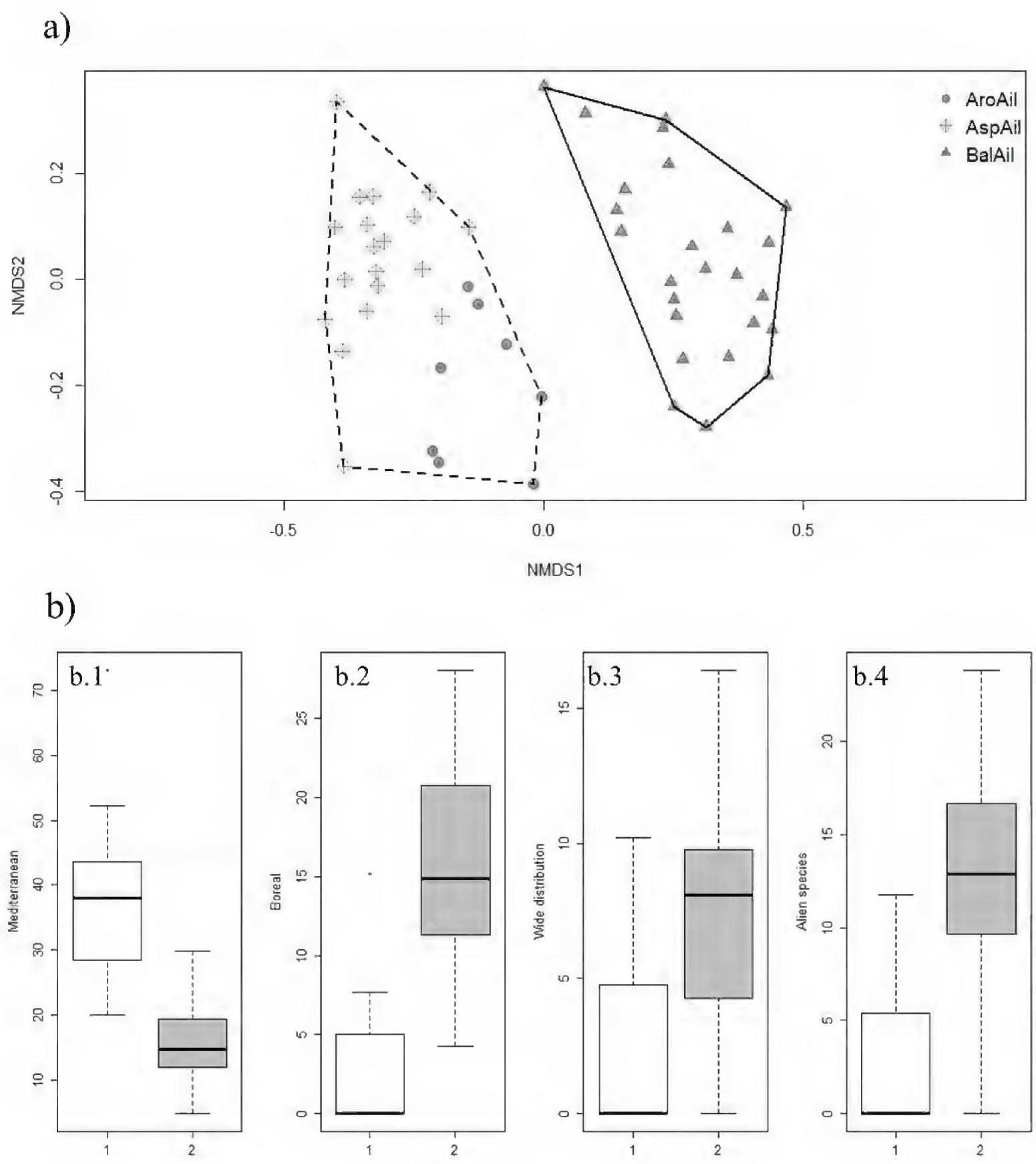

Figure 3. Ordination of the Italian and SE–European A. altissima forest associations and Box plots of chorological types. (a) NMDS scaling ordination plot (clusters are superimposed to NMDS plot) of the *A. altissima* forest coenoses here considered (dashed line) and *Balloto nigrae-Ailanthetum altissimae* from SE–Europe (continue line). Legend: Circles: *Aro italici-Ailanthetum altissimae*; Squares: *Asparago acutifolii-Ailanthetum altissimae*; Triangles: *Balloto nigrae-Ailanthetum altissimae*. (b) Comparison of the significant chorological types (weighted percentage values) between the new Italian *A. altissima* forest associations considered altogether (labelled as 1) and the *Balloto nigrae-Ailathetum altissimae* association (labelled as 2). (b.1) Mediterranean chorotype p value=2.84e–11; (b.2) Boreal chorotype p value=3.26e–11; (b.3) Wide distribution chorotype p value=1.95e–05; (b.4) Alien species (neophytes and archeopytes) p value =3.55e–10.

to what happens for the xerophilous and thermophilous communities of the order *Euphorbio cyparissiae-Robinietalia* of the class *Robinietea* shown in Vitkova and Kolbek (2010). Moreover, from an ecological point of view, the differences between *A. altissima* forests and the neighboring native forests were highlighted and proved for both *R. pseudoacacia* (Montecchiari et al. 2020a) and *A. altissima* forests (Montecchiari et al. 2020b). A great effort has been made in Europe to classify alien-dominated forest communities that previously were referred to different orders and classes. Therefore, at the current state of knowledge, the attribution to the *Robinietea* class seems to be the only way forward. Future studies in the Mediterranean area will better clarify the syntaxonomic position of the *A. altissima* communities of the *Lauro nobilis-Robinion pseudoacaciae* alliance currently belonging to the order *Chelidonio-Robinietalia* of the *Robinietea* class and also to better clarify the syntaxonomic framework of the *Robinietea* class in Europe.

Syntaxonomic scheme

ROBINIETEA Jurko ex Hadac et Sofron1980
CHELIDONIO-ROBINIETALIA PSEUDOACACIAE Jurko ex Hadac et Sofron 1980
Lauro nobilis-Robinion pseudoacaciae Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019
Asparago acutifolii-Ailanthetum altissimae ass. nova
Aro italici-Ailanthetum altissimae ass. nova

Other syntaxa quoted in the text

Agropyretea repentis Oberdorfer, Muller & Gors in Oberdorfer, Gors, Korneck, Lohmeyer, Muller, Philippi & Seibert 1967; *Ailantho altissimae-Robinietum pseudacaciae* Julve 2003; *Artemisietea vulgaris* Lohmeyer, Preising & Tüxen ex von Rochow 1951; *Balloto nigrae-Ailanthetum altissimae* Sîrbu & Oprea 2010; *Balloto nigrae-Robinion pseudoacaciae* Hadač & Sofron 1980; *Carpinion orientalis* Horvat 1958; *Chenopodietea* Br.-Bl. in Br.- Bl., Rousine & Negre 1952 p.p.; *Cratego-Prunetea* Tuxen 1962; *Euphorbio cyparissiae-Robinietalia* Vítková in Kolbek et al. 2003; *Fico-Ailanthetum altissimae* Lov. (1975) 1984 ("*Ailantho-Robinietum*" auct. adriat. pp non Gutte; Kvarner: "žiròvine"); *Fraxino excelsioris-Quercetea roboris* Gillet 1986 ex Julve 1993 class; *Galio-Urticetea* Passarge ex Kopecky´ 1969; *Lauro nobilis-Ulmion minoris* Biondi, Casavecchia, Gasparri & Pesaresi in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Poldini, Sburlino, Vagge & Venanzoni 2015; *Melisso altissimae-Robinetum pseudoacaciae* Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019; *Pruno avium-Carpinetalia betuli* Gillet 1986 ex Julve 1993; *Pruno spinosae-Rubion ulmifolii* O. Bolos 1954; *Pyro spinosae-Rubetalia ulmifolii* Biondi, Blasi & Casavecchia in Biondi, Allegrezza, Casavecchia, Galdenzi, Gasparri, Pesaresi, Vagge & Blasi 2014; *Quercetalia pubescentis-petraeae* Klika 1933; *Quercetea pubescenti–petrae* Jakucs 1960; *Quercion ilicis* Br.-Bl. ex Molinier 1934; *Querco roboris-Fagetea sylvaticae* Br.-Bl. & Vlieger in Vlieger 1937; *Rhamno-Prunetea* Rivas Goday & Borja ex Tuxen 1962; *Robinio pseudoacaciae-Ulmion minoris* Julve 1993; *Rubio peregrinae-Robinietum pseudoacaciae* Allegrezza, Montecchiari, Ottaviani, Pelliccia & Tesei 2019; *Salici purpureae-Populetea nigrae* Rivas-Martínez & Cantò ex Rivas-Martínez, Bàscones, T.E. Dìaz, Fernàndez-Gonzàlez & Loidi 2001; *Sisymbrietea* Gutte & Hilbig 1975; *Stellarietea mediae* Tuxen, Lohmeyer & Preising ex Von Rochow 1951; *Urtico-Sambucetea* Passarge & Hofmann 1968.

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Appendixes

Appendix I - Sporadic species

Table 1 - Rel. 1 : *Allium* sp. +; rel. 2: *Daucus carota* L. +; rel. 3: *Pseudoturritis turrita* (L.) Al-Shehbaz +; *Iris germanica* L. +, *Lunaria annua* L. +, *Malus* sp. +, *Narcissus* sp. +; rel. 4: *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz 3.4; *Colutea arborescens* L. 1.2; *Lagurus ovatus* L. +, *Tordylium apulum* L. +.2, *Verbascum sinuatum* L. +, *Erigeron canadensis* L. +; rel. 5: *Spartium junceum* L. +; *Bunium bulbocastanum* L. +, *Helleborus foetidus* L. +, *Origanum vulgare* L. +.2; rel. 6: *Artemisia campestris* L. +; *Geranium dissectum* L. +, *Umbilicus horizontalis* (Guss.) DC. +; rel. 7: *Acer pseudoplatanus* L. +; *Viburnum tinus* L. +; rel. 9: *Lonicera caprifolium* L. +; rel. 13: *Cruciata laevipes* Opiz +, *Mentha spicata* L. +, *Clinopodium vulgare* L. +; rel. 14: *Ligustrum lucidum* W.T.Aiton +, *Pyrus communis*

L. +, *Verbascum thapsus* L. +, *Galium mollugo* L. +; rel. 16: *Populus alba* L. +; rel. 18: *Rumex* cfr *sanguineus* +; rel. 19: *Corylus avellana* L. +; rel. 21: *Artemisia verlotiorum* Lamotte +.2, *Ligustrum japonicum* Thunb. +.

Appendix II - Relevès dates, localities and geographical coordinates (WGS84–UTM T33)

Table 1 - Rel. 1: 10/10/2019, Fossombrone (PU), Loc. San Lazzaro, 321483 E; 4839316 N; 33 T; Rel. 2: 01/10/2019, Fano (PU), Loc. Falcineto, 337141 E; 4848681 N; 33 T; rel. 3: 20/09/2019, Caldarola (MC), 349941 E; 4777643 N; 33 T; rel. 4: 12/10/2020, Marina di Massignano (AP), 405620 E; 4767840 N; 33 T; rel. 5: 24/09/2019, Serra san Quirico (AN), 338904 E; 4811611 N; 33 T; rel. 6: 19/06/2019, Castelfidardo (AN), 385604 E; 4814288 N; 33 T; rel. 7: 01/10/2019, Fano (PU), Loc. Monte Giove, 337132 E; 4853921 N; 33 T; rel. 8: 10/10/2019, Colli al Metauro (PU), Loc. Tavernelle, 329718 E; 4844106 N; 33 T; rel. 9: 10/09/2019, Fabriano (AN), Loc. san Michele, 333757 E; 4797518 N; 33 T; rel. 10: 10/09/2019, Fabriano (AN), Loc. san Michele, 334511 E; 4797268 N; 33 T; rel. 11: 20/09/2019, Belforte del Chienti (MC), 356709 E; 4779328 N; 33 T; rel. 12: 12/10/2021, Marina di Massignano (AP), 405974 E; 4768016 N; 33 T; rel. 13: 10/09/2019, Matelica (MC), Loc. Piane, 337494 E; 4796349 N; 33 T; rel. 14: 24/07/2019, Osimo (AN), Loc. Padiglione, 375354 E; 4813757 N; 33 T; rel. 15: 24/09/2019, Serra de' Conti (AN), 341462 E; 4824278 N; 33 T; rel. 16: 24/07/2019, Montefano (MC), 372499 E; 4805753 N; 33 T; rel. 17: from Fanelli 2002, Tab. 36, rel. n° 1; rel. 18: 19/06/2019, Macerata (MC), 375047 E; 4796378 N; 33 T; rel. 19: 10/09/2019, Matelica (MC), Loc. Colferraio, 339474 E; 4796335 N; 33 T; rel. 20: 18/10/2018, Castelplanio (AN), Loc. Macine-Borgo Loreto, 346354 E; 4816786 N; 33 T; rel. 21: 12/10/2019, Atri (TE), Loc. Colle Petitto, 418885 E; 4711689 N; 33 T; rel. 22: 18/10/2018, Moie (AN), 350779 E; 4818011 N; 33 T; rel. 23: 12/10/2018, Atri (TE), 418328 E; 4713782 N; 33 T; rel. 24: from Fanelli 2002, Tab. 36, rel. n° 4; rel. 25: from Fanelli 2002, Tab. 36, rel. n° 3; rel. 26: from Fanelli 2002, Tab. 36, rel. n° 7; rel. 27: from Fanelli 2002, Tab. 36, rel. n° 2.